Appendix

SOURCES AND METHODS FOR THE ECONOMIC AND MILITARY PROJECTIONS

This appendix describes the method used in estimating economic and military trends for the period 1950 through 2010 for 15 key countries: United States, Soviet Union, Japan, China, United Kingdom, France, Federal Republic of Germany, Turkey, India, South Korea, Taiwan, Egypt, Brazil, Mexico, and Argentina. The initial discussion is confined to the general theoretical framework applied to all of the countries. In some cases, further adjustments were made because of data limitations or for other reasons. More detailed explanations of these adjustments and of the specific data sources used for each country are presented in the sections below on individual countries.

METHODOLOGY

Economic Trends

To depict the gross magnitude of impending economic changes, we derived GNP estimates for the 15 countries from data and judgments concerning recent and pending changes in rates of capital formation, employment, and productivity. No single indicator suffices to convey the trend of an economy over time, still less to compare and size the performance of a large number of economies at any given point in time. Growth in real national product is clearly one salient indicator, but other ones are important and relevant, depending on the purposes for which the comparisons are intended. Other relevant indicators include capital flows, exports and imports, per capita income, domestic capital formation, resource allocations for research and development and science and technology, international holdings of assets and liabilities, and demographic changes.

Our initial evaluation of major economic trends focuses on gross national product because we are interested in examining economic trends for a large number of countries over a 60-year period—from 1950 to 2010—and GNP is probably the most useful single indicator of economic size for making international comparisons over long periods.

The estimates from the present to 2010 employ the same methodology that we used in reestimating the actual GNP figures for 1950 to the present; thus, the past and future series are intended to be consistent with one another.

The 15 countries we covered account for more than two-thirds of the global economic product (see Table 1), as well as the overwhelming preponderance of global military power (see Table 7). While none of these estimates is intended as a precise forecast, particular uncertainties surround estimates for the Soviet Union and China. To reflect these uncertainties, several alternative estimates have been made.

The basic model used in the estimates makes the simplifying assumption that output (gross national product or gross domestic product) can be represented as a Cobb-Douglas production function. The function specifically assumes constant returns to scale, two factors of production—capital and labor, and Hicks-neutral technological change. Equation (1) shows the functional form of the model:

$$GNP = C * (EXP(a * t)) * (K)^{b} * (L)^{1-b} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where,

C is a constant,

a is the rate of technological change,

t is years elapsed since the base year (1950),

b is the share of capital in GNP,

K is the index of capital input in a given year, and

L is the index of labor input in a given year.

The indices of capital input (K) and labor input (L) were estimated for each country. Measurement of both indices involves certain conceptual issues which are not addressed in the study.[1]

We have used these simple measures because our aim is to compare differences among nations, rather than to make precise forecasts of their individual GNPs; the simplified measures are less likely to affect relative GNP differences than they are to affect the GNP estimate of any individual country.

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[1]Capital services are difficult to estimate. Gross capital stock is the present value of future services that the capital stock will provide. If the lifetime of the capital stock is long, and the depreciation rate is constant among its various components, then the market value or the "net capital" measure serves as an appropriate proxy for capital service input. Or, if the lifetime and depreciation rate are constant among the various components of the capital stock, the "gross" measure is an appropriate proxy. However, uncertain equipment lifetimes and technological obsolescence make the assessment of input of capital services difficult. To keep the analysis simple, we use the gross capital stock as a proxy for the capital service input. Similar problems are encountered in calculating a labor input index. Labor can differ by hours worked, individual worker efficiency, educational level, and so on. These differences exist at each point in time, over periods of time, and across countries. In any event, for most countries such detailed data are not available, so we have used gross numbers of persons employed.

The capital stock in a given year is calculated by adding the depreciated sum of all previous investments and the new investment in the given year, as shown by Eq. (2). New investment in a given year is a function of the GNP in that year, as indicated in Eq. (3).

$$K_t = (1 - d) * K_{t-1} + I_t \quad \text{..... (2)}$$

where

K_t is capital stock at time t,

K_{t-1} is capital stock at time t-1,

d is the depreciation rate, and

I_t is new investment in year t.

$$I_t = s * GNP_t \quad \text{..... (3)}$$

where s is the share of GNP devoted to investment in year t.

In this formulation, the capital stock must be known for at least a single year to provide a benchmark value from which the whole stream of capital stock numbers can be generated. Except for the United States and the Soviet Union, total capital stock figures for a specific year were not generally available. To resolve this problem we assumed a ratio of capital stock to GNP in 1950 of about 2.5 for each of the 15 countries, based on the general experience of the United States and other countries, with modifications based on country-specific data.

The index of labor input was calculated as the ratio of total employed persons in a given year to employment in the base year, i.e., 1950. Parameters a and b in Eq. (1), representing technological change and the capital share in GNP, respectively, were estimated from the country-specific data for several of the countries, while in other instances these parameters were drawn from other sources and from prior development research.[2]

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[2]In general, it appears that the share of capital in GNP declines as nations industrialize. For most developing countries the capital share is around 0.45, while for the industrialized nations it is generally 0.35 but may be as low as 0.25. To retain consistency, the present analysis assumes that the share of capital in GNP for the developing nations is 0.45, while for the developed nations it is 0.35. For a good overview see Solow, R. M. (1957): "Technical Change and the Aggregate Productivity Function," *Review of Economics and Statistics*, 39, No. 3, pp. 312–320; Domar, E., et al. (1964): "Economic Growth and Productivity in the United States, Canada, United Kingdom, Germany and Japan in the Post War Period," *Review of Economics and Statistics*, 46, No. 1, pp. 33–40; Kendrick, J. W., and Vaccara, B. N., eds. (1980): *New*

Military Trends

Two gross indices were selected to provide a simple and reasonably comparable basis for assessing the aggregate military status of each country: total annual military spending, and military capital stock for each year of the 1950–2010 period. This, of course, abstracts from numerous other critical influences on military capabilities, such as leadership, training, morale, and logistics.

To estimate military spending, explicit and documented assumptions were made for each country regarding the fraction of GNP devoted to defense spending, in the past, at present, and in the future. Prior and current spending shares accord with actual experience. The future spending share was either assumed to replicate this pattern or was adjusted to accord with intended or anticipated changes in particular countries.

Measurement of the military capital stock presents more complex and difficult theoretical and empirical problems. Among these difficulties are the following: first, the "services" provided by military equipment are difficult to define and quantify; and second, the same piece of equipment can provide varying levels of effective service depending on the type of conflict, terrain, adversaries, allies, and other contingency-specific circumstances. Our methodology measures the value of the military capital based on procurement cost. This implicitly represents the value of services that a particular piece of equipment will provide, relative to other procurements, averaged over the possible scenarios in which it is expected to be used.

A further difficulty in measuring military capital relates to the possibility of accelerated obsolescence depending on the technology embodied in an adversary's military capital.

Additional empirical problems arise in determining what to count toward the military capital stock. Part of military capital budgets is devoted to construction and procurement of civil-type items like office equipment, appliances, and amenities. Whether to include or exclude such items depends on the question being asked.

Generally in our analysis, the military capital stocks of the respective countries were calculated using gross currency outlays for military procurement (principally weapons procurement where it could be separated from total procurements) and construction (covering barracks, airfields, communication facilities, and other structures).

Developments in Productivity Measurement and Analysis, The University of Chicago Press.

The methodology is similar to that applied to civilian capital stock described in Eqs. (2) and (3) above.

As with civilian capital estimates, military capital estimates require that we have a benchmark estimate for at least a single year to enable the entire series to be generated. In the absence of this benchmark figure, we have proceeded in two ways. For some countries, a starting value for the military capital stock in 1950 was estimated based on the amount of defense spending devoted to military investment in that year; we then built the subsequent years' estimates by adding new investment and depreciating the accumulated military capital stock. For other countries, the military capital stock in 1985 was estimated from their inventories of military equipment scaled to those of other countries in the sample; in this case, estimates for the earlier years were built up by subtracting each prior year's new military investment and adding depreciation from that year's existing capital stock.

Looking backward from 1985, the trend in military capital can be estimated by assuming the estimate for 1985 to be accurate and generating backward the capital stock figures for the earlier years from the corresponding military investments in those years and a different depreciation rate.

To determine suitable depreciation rates for the past and the future, this method was applied to the capital stock data for the United States, which is available for all prior years. An annual depreciation rate of 3.5 percent for the future and 4.5 percent for the past, gives a good approximation in the U.S. case. These rates, or close approximations, were applied to other countries as well.[3]

For most countries, data were not available concerning the exact proportion of the defense budget devoted to military investment. In these cases, assumptions were made based on their similarity with other nations whose corresponding figures were known;

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[3]Two exceptions are China and India for the 1985–2010 period. The rate used for China was 7.5 percent; use of this higher rate was considered to be reasonable because military modernization now is the last of China's four "modernizations." By the 1990s and into the next century, it is expected that substantial replacement of the Chinese military capital stock will begin and that the rate of retirement will accelerate. For India, a 3.5 percent rate was used for 1985–2010. This lower rate was believed justified because, while the Indian military is modernizing its equipment, available sources suggest a markedly low rate of retirement is likely to be maintained.

The military capital stock figures generated by the process described in the text were judged subjectively for their reasonableness based on general knowledge regarding the various countries.

e.g., the proportion of defense spending devoted to military investment in South Korea was assumed to apply to Taiwan, as well.

With respect to the estimates for 1987 through 2010, our analysis also assumes that each country's military spending decisions are independent of those of other nations; i.e., reactive effects were not modeled. In making the estimates for the 1987–2010 period, we used (1) military investment shares in total defense spending and (2) depreciation rates based on prior experience or on adjustments of prior experience based on judgments relating to the individual countries.

Currency Conversion

Most of the trend analysis was initially conducted in the separate national currencies of the countries in the sample and subsequently converted to constant price dollars, generally at the 1980 purchasing-power parity rate. There are some exceptions to this procedure (e.g., Argentina, Brazil, and China) for which the available historical data were already in dollars. The procedure used for each country is described in more detail in the following sections.

The currency conversion raises another question concerning the appropriate rate to use, that is, the prevailing exchange rate or a suitable "purchasing-power parity" (PPP) index. The PPP index was generally regarded as preferable.[4]

In general, the PPP index is more appropriate for converting GNP in national currencies to dollars, because it better reflects the real resource parities among currencies unaffected by short-term changes in capital movements and expectations. However, in the case of military capital stocks, the appropriate rate could differ from both the exchange rate and the PPP index because some military capital is procured at costs reflecting domestic prices (construction, indigenously manufactured equipment, etc.), while other military capital is procured at prevailing dollar exchange rates. Moreover, some military capital may be procured at prices that involve commodity "offsets" and associated transactions, which further obscure the actual conversion rate implicit in the acquisition.

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[4]The PPP rates are taken from Summers, R., and Heston, A. (1984): "Improved International Comparisons of Real Product and Its Composition: 1950–1980," *Review of Income and Wealth*, June, pp. 207–262. In general, PPP rates use the geometric mean of the foreign currency and dollar price ratios in the dollar conversions.

Thus, when interpreting the results, further caution is warranted because of the currency conversion process.

ARGENTINA

Data Sources

For the years 1950–1979, the GNP data were taken from the *Statistical Abstract of Latin America* (*SALA*), Vol. 24, Table 3324. Real growth rates for GNP for the period 1980–1985 were also taken from *SALA*, Table 3301. Gross capital formation (civilian investment) as a percent of GDP was taken from the same source, Table 3366, for the years 1962, 1965, 1970, and 1975–1982. For the period 1950–1961, we assumed that 20 percent of GNP was devoted to gross capital formation (probably an optimistic estimate), while for 1971–1974 the estimate was derived by interpolation. For the period 1983–1985, gross capital formation was assumed to be 17 percent of GNP and 17.5 percent thereafter, based on the experience of recent years.

Labor force projections were taken from *Labor Force 1950–2000*, published by the International Labor Office (ILO) in 1977. The growth rate for the period 1995–2000 was assumed to apply thereafter until 2010.

Data for annual defense spending as a proportion of GNP were from the annual *Stockholm International Peace Research Institute (SIPRI)* volumes; for years after 1985, defense spending was assumed to be 2.5 percent based on a weighted average of the recent years' experience. Military capital investment was assumed to average 25 percent of total defense expenditures based on the experience of most non-U.S. NATO countries. The exceptions are 1982 when it was assumed to be 10 percent and 1983 when it was assumed to be 40 percent, because of the Falkland war.

Estimation

The GNP for years beyond 1985 was estimated using the production function method described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change was assumed to be 0.5 percent. To obtain the annual civilian capital stock numbers, we assumed that in 1950 the ratio of the capital stock to the GNP was 2.5, based on the historical experience of the United States. The annual rate of depreciation for civilian capital was assumed to be 5 percent.

The military capital stock was derived by the "past and future" approach described earlier. The depreciation rate for computing in the future direction was assumed to be 3.5 percent and in the past direction, 5 percent. Once having estimated the 1985 figure by means of the "future" method, the imputed figures for the earlier years were derived and used based on "past" calculations employing the 5 percent depreciation rate.

The data reported in *SALA* are already given in dollars, so no conversion is necessary. It is not clear, however, whether these data were originally converted using the exchange rate or a PPP index.

BRAZIL

Data Sources

As with Argentina, GNP data were taken from *SALA*, Table 3324, for the period 1950–1980. The annual GNP growth rates for the years 1981–1985 are available from the same source, Table 3303, and were used to derive the actual GNP figures for those years. Data for the gross fixed capital formation for the years 1962, 1965, 1970 and 1975–1983 are from *SALA*, Table 3366. Gross fixed capital formation was assumed to be 20 percent of GNP for the period 1950–1961, 21.25 percent for the years 1983–1985, and 21 percent subsequently. The latter two figures are based on the weighted average of the most recent years for which gross capital formation data were available. Implicit compound growth rates were computed for the intervals 1966–1969 and 1971–1974, and figures applicable for the various years in those intervals were interpolated.

The labor data are taken from the ILO publication, *Labor Force 1950–2000*, cited earlier. The growth rate for the period 1995–2000 was assumed to hold until 2010.

Defense spending as a proportion of GNP is taken from the *SIPRI* volumes; for the years after 1985, it is assumed to be 0.7 percent, based on the experience of recent years. It is also assumed that 25 percent of the defense budget is devoted to capital expenditures for all years, based on the general experience of the non-U.S. NATO countries.

Estimation

The GNP forecasts are based on the production function model described earlier. Capital's share in GNP was assumed to be 0.35 for all the years, and the annual rate of technological change was assumed to be 1.5 percent for years beyond 1985, reflecting a belief in the continued progress of the Brazilian economy. The civilian capital stock

series was constructed based on the assumption that the ratio of the capital stock to GNP in 1950 was 2.5, based on the historical experience of the United States and other countries. The annual depreciation rate for civilian capital was assumed to be 5 percent.

The military capital stock series was derived using the "future and past" approach described earlier. The depreciation rates used in the future and past directions were 3.5 and 5 percent, respectively.

No currency conversion is necessary as the data reported in *SALA* are already in dollars. Once again, it is not clear whether the data were originally converted using the exchange rate or a PPP index.

CHINA

Data Sources

The GDP (in 1980 dollars) for the years 1950 through 1980 were taken from Herbert Block, *The Planetary Product in 1980*, U.S. Department of State, Washington, D.C., 1981, pp. 42–43. These estimates are believed to be more reliable than the official Chinese figures. Estimates of GDP for the years 1981 through 1985 were obtained by applying a growth rate (derived from the Chinese estimates for that period) to Block's estimate for 1980: this official Chinese growth rate was judged to be more reliable than the GDP estimates themselves. The Chinese GNP estimate for 1980 in yuan was taken from Liu Guoguan, "On the Strategic Objectives of China's Economic Development," *Caimou jingji (Economics of Finance and Trade)*, 1983, No. 1, p. 5. The GNP estimate for 1985 in yuan was taken from *Zhongguo tongji nianjian 1986 (China Statistical Yearbook 1986)*.

Labor force data were from State Statistical Bureau, *Guanghui di san-shi-wu nian (The Glorious Thirty-Five Years)*, China Statistics Publishing House, Beijing, 1984, p. 152. In the above data series, the labor force figures for 1950 and 1951 were missing; these were interpolated based on the assumption that the growth rate of the labor force was constant between 1949 and 1952. For the 1990s and beyond, labor input was estimated to grow at an annual rate of 1.5 percent. This low figure reflects assumptions of a successful family planning program and the increasing aging of the Chinese population.

Defense spending data were derived indirectly. For 1980 the defense spending figure was an average of high and low estimates from *World Military Expenditures and*

Arms Transfers, 1971–80, U.S. Arms Control and Disarmament Agency. Defense spending figures in yuan for the period 1950–1985 were also taken from the *Statistical Yearbook 1986*. First these yuan figures were converted into 1980 constant prices and then an index was created from the yuan estimates, with the mean defense spending in 1980 being equal to one. From this basis, the full stream of defense spending figures in dollars was derived. This approach was adopted because the yuan estimates published by the Chinese government are likely to have been inflated. The mean proportion of GDP devoted to defense was 3.1 percent in 1985 according to the above method.

The amount of defense spending devoted to military capital was estimated through several steps. Estimates in (1974 constant prices) yuan were available for the years 1967 through 1983 from the Defense Intelligence Agency (DIA), *Chinese Estimated Defense Expenditures, 1967–83*, Washington, D.C., 1984, p. 13. The figure for 1966 was again a DIA estimate taken from *Defense and Economy*, Washington, D.C., 1980, pp. 3–4. Estimates for the years 1950 through 1965 were based on a regression of military investment on the gross value of output of the machine building sector (excluding farm machinery) for the period 1965–1971.

The amount of defense spending devoted to military capital was then converted into 1986 dollars in two different ways. A "high" estimate resulted from converting 1974 yuan into 1974 dollars using a purchasing-power parity index and then inflating 1974 dollars to 1986 dollars. The only PPP index that is available for China is for 1957 and is taken from the Central Intelligence Agency, *Yuan-Dollar Price Ratios for Communist China & the U.S. in 1957*, April 1964. This PPP index was used to convert 1974 yuan into 1974 dollars, which were then inflated into 1986 dollars. The underlying assumption is that the PPP index in 1974 is the same as in 1957. The "low" estimate was derived in the same fashion, except that a lower proportion of defense spending in GNP was assumed.

The actual figures for military capital investments are not shown; what is shown, however, is their depreciated sum to arrive at the military capital stock estimate. As we have two sets of estimates of the amount of defense spending devoted to military capital in each year, we obtain high and low estimates of the military capital stock. These two estimates served as bounds, from which the midpoints were calculated that are shown in Table 5 and Fig. 9. The technique by which the military capital investment estimates were converted into military capital stock figures is described below.

Estimation

The GNP forecasts are based on the production function model described earlier. The only difference is that the capital stock is not calculated explicitly. Instead, it is assumed that the capital stock grows at an average annual rate of 8.0 percent from 1985–1995 and 7.0 percent from 1995–2010. This reflects an averaging of the experiences of countries like Japan and South Korea, which had annual capital stock growth rates of 10 percent or more in past years, and India, whose capital stock annual growth was about 5 or 6 percent on average. The average annual rate of technological change, estimated to be zero in the years prior to 1985, was assumed to be 0.50 percent from 1985–1995 and 1.0 percent from 1995–2010 based on the historical experience of other countries which we considered applicable to China. The share of capital in GNP was assumed to be 0.4.

Defense spending is forecast to rise from 3.1 percent of GNP in 1985 to 3.5 percent of GNP from 1986–1990, 4.3 percent from 1991–1995, 5.0 percent from 1996–2000, and 6.0 percent from 2001–2010. The proportion of defense spending that is devoted to military capital is adopted from the "high estimate" described earlier: 30 percent from 1986–1995, 35 percent from 1996–2000, and 40 percent from 2001–2010. The corresponding figure in all years for the "low estimate" is 66 percent. The relatively high proportions of defense spending assumed to be devoted to military capital reflect the force modernization programs of the Chinese military establishment.

The military capital stock for the historical period is calculated using the "forward and backward" approach. The annual depreciation rates used are 3.5 percent in the forward direction and 5.0 percent in the backward direction. For the forecast years the annual depreciation rate applicable to military capital is expected to be higher in the Chinese case because of the force modernization and equipment retirement programs that the Chinese military establishment is likely to implement in the future. Accordingly, we have assumed the annual depreciation rate for military capital to be 7.5 percent from 1985–2010.

EGYPT

Data Sources

National accounts data for Egypt were taken from *International Financial Statistics, 1986*, published by the International Monetary Fund (IMF). These include the historical estimates of GNP and gross capital formation. For the forecast period, 1985–2010, we assumed that 20 percent of the GNP will be devoted to gross capital formation, based on the experience of recent years.

Labor force data and projections for the future were taken from the ILO publication, *Labor Force 1950–2000*. The labor force projections were modified, however, to take into account a rising level of unemployment and underemployment. We assumed that the employed labor force grows at only 80 percent of the growth rate that is implied by the ILO projections.

Defense spending data were taken from the annual *SIPRI* volumes. For the forecast period 1985–2010, we assumed defense spending to be 7.5 percent of GNP, based on the experience of recent years. Because of lack of data regarding the proportion of defense spending devoted to military capital, we assumed that 25 percent of defense spending was devoted to military capital for all the years based on the general experience of the non-U.S. NATO countries.

Estimation

The GNP was estimated by the method described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change was assumed to be 0.2 percent. The ratio of the civilian capital stock to GNP in 1950 was assumed to be 2.5, and capital stock estimates for the later years were calculated based on that assumption. The annual depreciation rate used for civilian capital was 5 percent.

The military capital stock was derived by the "forward and backward" estimation method described earlier. The annual depreciation rates used were 3.5 percent and 5 percent in the forward and backward directions, respectively.

All calculations were performed in the national currency and then converted into dollars using the appropriate PPP index.

FEDERAL REPUBLIC OF GERMANY

Data Sources

The GNP and civilian gross investment from 1950 through 1985 were obtained from the *International Financial Statistics, 1985*, published by the International Monetary Fund. Analysis of these data indicates that the share of civilian investment in GNP in 1985 was about 20 percent, and this was assumed to hold for the entire forecast period.

Labor data for the period 1960–1980 were from the Organization for Economic Cooperation and Development (OECD), *Historical Statistics: 1960–1980*, Paris, 1982. For years after 1980, the data were from the U.S. Bureau of the Census forecasts.

Historical defense spending for the period 1950–1985 was from data published by Program Analysis and Evaluation (PA&E), Office of the Secretary of Defense. Based on historical experience, we assumed that West Germany will devote roughly 3.2 percent of its GNP to defense. Using the *Report on Allied Contributions to the Common Defense*, Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of defense spending was devoted to military capital. This figure is assumed to apply for the subsequent years, as well.

Estimation

The GNP was estimated according to the model described earlier. The share of capital in GNP was assumed to be 0.35, and annual technological change was 1.5 percent. The civilian capital stock was calculated by assuming that the ratio of the capital stock to GNP in 1950 was 2.5. The annual depreciation rate used for civilian capital was 5 percent.

The military capital stock was forecast using the "forward and backward" approach, with depreciation rates of 3.5 and 4.5 percent, respectively.

Estimates in marks were converted to dollars using the PPP index.

FRANCE

Data Sources

The GNP and civilian gross investment from 1950 through 1985 were obtained from *International Financial Statistics, 1985*. Analysis of these data indicates that the share of civilian investment in GNP in 1985 was approximately 19 percent. This figure was assumed for the entire forecast period.

Labor data for the period 1960–1980 were taken from *Historical Statistics: 1960–1980*, OECD, Paris, 1982. For years after 1980, the data were from the U.S. Bureau of the Census forecasts.

Historical defense spending for the period 1950–1985 was taken from the data published by the Office of the Secretary of Defense. Based on historical experience, we assumed that France will devote about 3.3 percent of its GNP to defense. Based on the *Report on Allied Contributions to the Common Defense*, Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of French defense spending is devoted to military capital. This was assumed to apply in the future, as well.

Estimation

The GNP was estimated in the usual way, as described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change, 1.5 percent. The civilian capital stock was calculated by assuming that the ratio of the capital stock to GNP in 1950 was equal to 2.5. The annual depreciation rate used for civilian capital is 5 percent.

The military capital stock is forecast using the "forward and backward" approach, with corresponding depreciation rates of 3.5 percent and 4.5 percent, respectively.

Estimates in francs were coverted to dollars using the PPP index.

INDIA

Data Sources

The national accounts data for the period 1950–1984, including estimates of GNP, gross fixed capital formation (annual investment), inflation (GDP deflator), and total population, are from *International Financial Statistics* published by the International Monetary Fund. For the forecast years, we assume that gross capital formation increases linearly from 21 percent in 1984 to 25 percent in 2010, reflecting the general trend observed in other Asian countries.

For the years after 1984, labor supply figures were derived from United Nations' forecasts. We assumed that the labor force grows with the cohort of all those between ages 15 and 64.

The share of GNP devoted to defense for the various years is taken from the *SIPRI Yearbook, 1974*, and *World Military Expenditures and Arms Transfers, 1965–1974 & 1985*, published by the Arms Control and Disarmament Agency (ACDA). For the future, we assumed that 4 percent of GNP is devoted to defense spending. This figure is slightly higher than the 3.5 percent experience of recent years, reflecting India's force modernization programs and the expansion of the Indian Navy.

The above sources do not indicate the percentage of defense expenditures devoted to military capital, but the fraction of the defense budget devoted to military capital expenditures, for certain years, is available in the *Statistical Outline of India*, published by Tata Industries, Bombay. (Figures for the missing years were obtained by interpolation.) These statistics are presumably compiled from various government documents. It is, however, not clear what types of outlays are covered by military capital expenditures. For the 1990–2010 period, we assumed that 20 percent of defense spending is devoted to military capital.

The proportion of defense spending devoted to military capital reflects the general historical trend, but is expected to be maintained at a level somewhat below that of the NATO countries because of the labor-intensive structure of India's forces and the mountainous terrain characterizing its vast border with China.

Estimation

The GNP is forecast according to the same method used for the other countries. The share of capital in GNP was estimated to be 0.45. The parameter a, for the rate of change of technological productivity, was estimated to be not significantly different from zero.

To obtain the stream of the civilian and military capital stock values, assumptions were made regarding their reasonable values in 1950. These served as the starting values. The civilian capital stock was estimated as 1.3 times the GNP based on assumptions concerning investment, GNP levels and growth, and depreciation rates (5 percent) in the period prior to 1950.

For the military capital stock in 1950, we assumed that the share of defense expenditure devoted to "capital" was only for purposes of making up for depreciation, without new investment. Under such an assumption, the capital stock is equal to the capital expenditure divided by the depreciation rate. The above assumption seems reasonable as in 1950, just three years after independence, the national focus was largely

on development and not defense. The annual 1985–2010 depreciation rate used for military capital is 3.5 percent because while the Indian military is engaged in a modernization program, retirement rates are expected to be low, in contrast to the Chinese case.

JAPAN

Data Sources

The principal data source for the Japanese economy is the *Annual Report on National Accounts, 1986*, and its earlier edition, the *Annual Report on National Income Statistics, 1970*, published by the Economic Planning Agency. An additional source is the *Japan Statistical Yearbook (1960–1983)*, compiled by the Statistics Bureau of the Management and Coordination Agency. For the forecast period, gross capital formation (civilian investment) was assumed to be 28 percent of GNP, based on the average of previous years.

The labor input into the Japanese economy was assumed to be the total number of persons employed.

Military expenditure data were from the *Defense Yearbook* (Boei Nenkan, 1953–1974); *Yearbook of the Self-Defense Forces* (Japan Defense Agency, Tokyo, 1963–1974); and *Defense of Japan* (Japan Defense Agency, Tokyo, 1976–1986). There is an unexplained discrepancy of about 7 to 10 percent between the figures for the military budget and the actual expenditures. However, budget figures are preferred because they provide a breakdown of total planned outlays, which is required for computing the military capital stock.

For the forecast period, we assumed, as the base case, that 1 percent of the GNP is devoted to defense spending, based on the experience of the last decade or so. Another case where Japan devotes 3 percent of its GNP to defense spending was also estimated, to bound the forecasts. The proportion of defense spending devoted to military capital was assumed to be 25 percent for the future years based on the historical average.

Estimation

The economic trends are forecast using the familiar production function method. For 1980–1984, the capital share in GNP was estimated to be 0.37 and the annual rate of technological change 1.3 percent; both figures are assumed to hold for the forecast period

also. The results of this direct estimation corroborate the general results of research in economic development and increase the credibility of our assumptions for countries where direct estimates of these parameters were not made. The annual rate of depreciation for civilian capital was assumed to be 6 percent, based on historical data.

For the military capital stock, data are available for the years since 1950. The full stream is built from 1950 onwards using an annual depreciation rate of 5 percent.

Note that all calculations are performed in the national currency and then converted to dollars using the PPP index. For Japan, however, the exchange rate and the PPP index differ only slightly in 1980.

MEXICO

Data Sources

National accounts data for Mexico, including estimates of GNP and gross capital formation, are from the *International Financial Statistics, 1986*, published by the IMF. For the forecast period, it was assumed that 20 percent of GNP would be devoted to gross capital formation.

Labor force data were from the ILO publication, *Labor Force 1950–2000*. These projections were modified to take account of a rising level of unemployment and underemployment. We assumed that employment growth would be 80 percent of the total labor force growth rate implied by the ILO projections.

Defense spending data were taken from the *SIPRI* volumes. For the forecast period, annual defense spending was assumed to be 0.6 percent of GNP, based on recent experience. The proportion of annual defense spending devoted to military capital was assumed to be 25 percent, based on the general experience of other countries.

Estimation

The GNP was forecast using the standard production function model. The share of capital in GNP was assumed to be 0.35 and the annual rate of technological change, 0.2 percent, reflecting Mexico's experience in the last decade, as well as the recent downturn in the Mexican economy. The ratio of civilian capital stock to GNP in 1950 was assumed to be 2.5. The civilian capital stock estimates were made a assuming 5 percent annual depreciation rate.

Military capital stock estimates were based on the "forward and backward" approach, described earlier. Annual depreciation rates for military capital were 3.5 percent and 5 percent for the forward and backward directions, respectively.

Calculations were made in national currency and then converted to dollars using the PPP index.

SOUTH KOREA

Data Sources

South Korea's GDP and civilian investment figures for the period 1953–1984 were taken from the IMF's *International Financial Statistics (IFS)*. For the later years, it was assumed that 30 percent of GDP would be devoted to civilian capital investment, based on South Korea's experience over the past decade.

The population cohort between ages 15 and 64 was used as a proxy for the labor input. For the years previous to 1985, this cohort was estimated by multiplying the *IFS* population data by the percent of working age, derived from the World Bank's *World Development Reports* (*WDR*). For the forecast years, labor supply is based on the U.S. Census Department population forecasts by age category, with interpolation for missing years.

The estimates of military spending and military capital are based on data from the Korea Institute for Defense Analysis in Seoul. These data were available only for 1961 through 1982. For the future years, the share of GDP devoted to defense and the share of defense spending devoted to military capital were assumed to be the same as in 1982; namely, 5.8 percent and 31.8 percent, respectively.

Estimation

The GDP is forecast using the production function approach. The capital share of GDP was assumed to be 0.45 and the annual rate of technological change, 1.5 percent, representing the average rate of technological change observed for 1975–1984. The civilian capital stock was calculated iteratively so that the ratio of investment to capital stock in the base year is equal to the average level for the entire period. The annual depreciation rate for the above calculation is assumed to be 5 percent.

The military capital stock was also derived iteratively, using an annual depreciation rate of 5 percent.

National currency values are transformed into dollars using the exchange rates published in the *International Financial Statistics.*

TAIWAN

Data Sources

The GDP (1980 constant dollars) for the years 1950 through 1980 were from Herbert Block, *The Planetary Product in 1980*, U.S. Department of State, Washington, D.C., pp. 36–37. For the years 1981 through 1985, GDP is based on a GDP index in 1981 constant prices based on data in *Industry of Free China*, January 1987, p. 50.

Labor force data are from the *Taiwan Statistical Data Book 1985*, Council for Economic Planning and Development, Taiwan, 1985. For the forecast period, the labor force is expected to grow at roughly 2 percent annually.

Defense spending data for 1961 through 1983 were from *World Military Expenditures and Arms Transfers* (various issues) published by ACDA. Estimates of defense spending for 1954 through 1960 were derived by regressing defense spending on total government expenditures for the period 1961–1970. Data on government expenditures and defense spending for 1961–1970 were taken from the previously cited *Taiwan Statistical Data Book 1985*. For the years prior to 1953, defense spending was derived on the assumption that the defense burden as a fraction of GNP was the same as in 1954. For 1984–1985, defense spending was based on the 1983 figure and an index of defense spending in the *Statistical Yearbook of the Republic of China 1986*, Waiwan, Taipei, p. 179.

Military investment as a proportion of defense expenditure was assumed to be the same as that for South Korea—see Charles Wolf et al., *The Changing Balance: South and North Korean Capabilities for Long-Term Military Competition*, The RAND Corporation, R-3305/1-NA, December 1985, p. 47.

Estimation

The GDP was estimated in the usual way. As in the case of China, the civilian capital stock was not explicitly derived. Instead, it was assumed to grow at an annual rate of 4 percent. The capital stock growth rate is based on data contained in Wu Hui-lin, *The Estimation and Application of Capacity and Capital Utilization Rates in Taiwan*, Chung-Hua Institution for Economic Research, Taipei, 1983, pp. 67–69. The annual rate

of technological change was assumed to be 3 percent based on Taiwan's experience in the 1970s. The share of capital in GDP is assumed to be 0.4.

Annual defense spending as a fraction of GDP was assumed to be 6 percent, based on recent experience, and the proportion of defense spending devoted to military capital was assumed to be 29 percent, the same as that for South Korea. Annual depreciation for military capital was assumed to be 8 percent. Military capital stocks were estimated employing the general methodology described earlier.

TURKEY

Data Sources

The GDP figures from 1950 through 1984 are from PA&E, Office of the Secretary of Defense. For the future years, we assumed that the proportion of GDP devoted to civilian capital investment rises from 25 percent in 1981 to 30 percent in 2010, based on recent historical experience and the trend in gross capital formation in other rapidly developing countries.

Labor input is estimated as the population between ages 15 and 64. For the years prior to 1985, we used the *IFS* population data multiplied by the percent of the working age population, according to the *WDR*. For the forecast years, the labor figures are based on the U.S. Census Department population forecasts by age category. Both series required interpolation for the missing years, based on an exponential function for the population series and linear interpolation for the working age group.

The defense spending estimates were based on PA&E estimates. For the forecast years, the proportion of GDP devoted to defense was assumed to be 4.5 percent, the same as for 1985. The proportion of defense spending devoted to military capital was assumed to be 25 percent.

Estimation

The GDP was forecast using the production function approach. The capital share of GDP was assumed to be 0.45 and the rate of technological change, zero, reflecting past experience. The civilian capital stock is calculated iteratively so that the ratio of investment to capital stock in the base year is equal to the average level for the entire period. The annual depreciation rate for the above calculation is assumed to be 5 percent.

The military capital stock was derived as described above, using an annual depreciation rate of 5 percent.

National currency values were converted to dollars using the exchange rates published in the *International Financial Statistics.*

UNITED KINGDOM

Data Sources

The GNP and civilian gross investment figures from 1950 through 1985 were from the *International Financial Statistics, 1985*, published by the IMF. The data indicate a share of civilian investment in GNP in 1985 of about 17 percent, and this was assumed to hold for the subsequent years, as well.

Labor data for the period 1960–1980 were from *Historical Statistics: 1960–1980*, OECD, Paris, 1982, and for subsequent years from U.S. Bureau of the Census forecasts.

Defense spending for 1950–1985 is from PA&E, Office of the Secretary of Defense. For the forecast period, we assumed that the UK will devote roughly 5.3 percent of its GNP to defense. Based on the *Report on Allied Contributions to the Common Defense*, a Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of defense spending has been and will be devoted to military capital.

Estimation

The GNP is forecast using the production function approach, assuming a capital share in GNP of 0.35 and an annual rate of technological change of 1 percent. The civilian capital stock was calculated based on the assumption that the ratio of the capital stock to GNP in 1950 was equal to 2.5 and using an annual depreciation rate of 5 percent.

The military capital stock was forecast using the "forward and backward" approach described earlier, with depreciation rates of 3.5 and 4.5 percent, respectively.

Estimates in sterling were converted to dollars using the PPP index.

SOVIET UNION

Data Sources and Estimation

Historical GNP, civilian investment, and defense spending data in 1970 rubles were from *USSR: Measures of Economic Growth and Development, 1950–1980*, Joint Economic Committee, Congress of the United States, December 8, 1982. GNP and defense spending data have been updated to 1985 as the base forecast year, using *Gorbachev's Modernization Program: A Status Report*, prepared by the Central Intelligence Agency for the Subcommittee on National Security Economics of the Joint Economic Committee, Congress of the United States, March 19, 1987. Information contained in Vasiliy Selyunin and G. Khanin, *Cunning Figures*, NOVY MIR, February 1987, pp. 181–201, indicates that economic growth from 1980–1985 was considerably lower than estimated by the U.S. intelligence community. The Selyunin-Khanin data were used to construct the base-case estimates.

Using our update of *Gorbachev's Modernization Program*, civilian investment is estimated at about 33 percent of GNP in 1985, while Selyunin-Khanin material indicates civilian investment of about 29 percent of GNP in that year.

Civilian capital stock data through 1980 are contained in *Soviet Statistics on Capital Formation*, Central Intelligence Agency, SOV 82-10093, August 1982. The capital stock data can be updated through 1985 using *Gorbachev's Modernization Program*, or using Soviet data combined with Selyunin-Khanin's conclusion that annual inflation in the Soviet investment data was 5 percent. The latter updating approach was used in constructing the base-case estimates. Our analysis of the historical civilian capital stock data indicates that Soviet civilian capital stock depreciates at about 3.5 percent per year, and this rate has also been used for the forecast period.

Labor force data are contained in Stephen Rapawy and W. Ward Kingkade, *Estimates and Projections of the Labor Force and Civilian Employment in the U.S.S.R.: 1950 to 2000*. These data have been updated to 2010 using population data from Ward Kingkade, *Estimates and Projections of the Population of the USSR by Major Nationality: 1979 to 2050*, Bureau of the Census, December 1986.

When the data since the mid 1970s are updated based on *Gorbachev's Modernization Program*, a labor share of 0.65 with no growth in total factor productivity can be inferred. However, using Selyunin-Khanin results in a labor share of 0.85 with no growth in total factor productivity over the 1974/5–1985 period.

The historical share of defense spending allocated to military investment is contained in *Estimated Soviet Defense Spending: Trends and Prospects*, CIA, SR 78-10121, June 1978. A military capital series was constructed for 1950–1985 using the "forward and backward" approach described earlier, with depreciation rates of 3.5 percent and 4.5 percent, respectively.

To convert GNP from 1970 rubles to 1985 dollars, data in *Gorbachev's Modernization Program* were employed. To convert defense spending and military capital to 1985 dollars, we employed *The Annual Report to the Congress, Fiscal Year 1987*, Caspar W. Weinberger, Secretary of Defense, and *The FY 1987 Department of Defense Program for Research and Development*, Statement by the Under Secretary of Defense, Research and Engineering to the 99th Congress, Second Session, 1986.

Base Case

Based on the previously cited report prepared for the U.S. Congress, the ratio of Soviet GNP to U.S. GNP was roughly 0.53 in 1980. Data from Selyunin-Khanin, indicating very slow growth between 1980 and 1985, were used to update the 1980 GNP and civilian capital figures to 1985. Using the CIA estimate of Soviet defense spending in 1970 rubles, one obtains a defense burden of 15 percent in 1985. Also as indicated above, labor's distributive share was assumed to equal 0.85 in the base case, and the capital share 15 percent.

In the base case, we assumed that there was zero growth of total factor productivity through 1990, and 0.5 percent annual growth for the remainder of the forecast period.

Alternative A: *Perestroika* Succeeds

The 1980 GNP estimate obtained from *USSR: Measures of Economic Growth and Development* was updated using *Gorbachev's Modernization Program.* As in the base case, the ratio of Soviet GNP to U.S. GNP was assumed to be 0.53 in 1980. Using CIA data on Soviet defense spending in 1970 rubles implied a burden of 14 percent.

Civilian capital stock data contained in *Soviet Statistics on Capital Formation* were updated using *Gorbachev's Modernization Program.* Based on the previous labor series, forecasts were made assuming that labor's share of GNP is 0.65; total factor productivity was unchanged through 1990 and grew at an annual rate of 1.5 percent thereafter.

Alternative B: *Perestroika* Falls

In this case, Soviet GNP was assumed to be only 40 percent that of the United States in 1980, reflecting a judgment by various analysts that the 53 percent used in the base case is unrealistically high. The 1980 GNP figure was updated to 1985 using the slow-growth estimates of Selyunin-Khanin for the intervening years. The military burden in 1985 was assumed, in this case, to be 20 percent. Using the specified labor series, forecasts were made under the assumption that labor's distributive share was 0.85 and that total factor productivity was unchanged through 1990 and grew at a 0.5 percent annual rate thereafter.

Alternative C: *Perestroika* Succeeds

In this case, the assumptions were the same as in Alt. B except that total factor productivity growth was assumed to be 1.5 percent after 1990. By using a more conservative estimate of Soviet GNP for 1980 compared with Alt. A, this scenario provides a lower bound to Soviet economic and military potential in the eventuality that *perestroika* succeeds.

Alternative D: *Perestroika* Succeeds

This alternative is the same as Alt. A except that Soviet military spending was held constant at the 1990 level (314 billion 1986 U.S. dollars) throughout the 1990–2010 period. Hence, as a proportion of GNP, defense spending would fall from 13.1 percent in 1985 to 6.7 percent by 2010.

UNITED STATES

Data Sources

Historical figures regarding GNP are taken from the *Economic Report to the President (ERP), 1987*. Data for the civilian capital stock are taken from John C. Musgrave, "Fixed Reproducible Tangible Wealth in the United States: Revised Estimates," *Survey of Current Business*, January 1986. For the forecast period (1986–2010), the proportion of GNP invested in civilian capital was assumed to be 16.3 percent, representing the average for 1980–1985.

Data for the labor input and gross civilian investment are also from the *ERP*. For the forecast period, labor is expected to grow at the 1980–1985 annual rate of 1.0 percent.

Data for defense spending are also from the *ERP*. The proportion of defense spending devoted to military capital was drawn from data of the U.S. Department of Commerce (DOC), which will be published soon. The DOC data break military capital into procurement and construction. Although procurement is probably more representative of military potential in a narrow sense, we use both components combined to obtain the U.S. military capital stock estimates, for reasons of comparability with other countries.

We assumed that the ratio of GNP devoted to defense remains at 6.2 percent (1980–1985 average) for the entire 1986–2010 period. The share of the defense budget devoted to procurement was assumed to be 29 percent and that to construction, 2 percent, representing averages for 1962–1986. The annual depreciation rates assumed for the above two components of the military capital stock were 5.8 percent (1950–1985 average) and 1.7 percent (1980–1985 average), respectively. For the depreciation rate applicable to military equipment, the 5.8 percent average over the full historical period was used because the 1980–1985 average (0.039 percent) was considered unrepresentative—it reflects the rapid equipment buildup of the last few years.

Estimation

The GNP is forecast using the standard production function approach employed for all the countries in the samples. We assumed that the capital share in GNP is 0.35 and that the annual rate of technological change is 1.0 percent (1980–1985 average). The civilian capital stock series for the forecast period was constructed using an annual depreciation rate of 2.3 percent (1980–1985 average).

The military capital stock was constructed in a similar manner, based on our data for defense spending and military capital investment and on the appropriate depreciation rates for the two components.